The Sidereal Messenger.

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory.

OCTOBER, 1886.

CONTENTS:

By faith we understand that the worlds have been framed by the word of God, so that which is seen hath not been made out of things which do appear.

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NORTHFIELD, MINN.

CARLETON COLLEGE OBSERVATORY.

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The Sidereal Messenger,

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider." — GALILEO *Sidereus Nuncius*, 1610.

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THE MERIDIAN CIRCLE OF THE LICK OBSERVATORY.

GEO. C. COMSTOCK.*

For the Messenger.

Through the kindness of the Lick trustees I was invited to spend a portion of the past summer at Mt. Hamilton, and the meridian circle of the Lick observatory was placed at my disposal while there. The opportunity thus afforded was employed in making a preliminary study of the character and performance of the instrument, some portions of which may be of interest to readers of the SIDEREAL MESSENGER.

The summit of Mt. Hamilton, originally a sharp peak, has, by blasting and removing the *debris*, been transformed into a plateau barely large enough to furnish room for the observatory buildings and the offices connected with them. Upon the north-eastern verge of this plateau stands the meridian circle house so close to the edge that from the north end of the transit slit a stone may easily be tossed across the winding road that leads up the mountain far down into the deep canyon that forms its northern limit. At the southern edge of the plateau is mounted the azimuth mark or "mire" at a distance of less than one hundred feet from the meridian circle. West of the meridian circle house is the transit room connected with the former by a tower placed between the two buildings, and still beyond is the dome for the twelve inch

* Professor of Mathematics and Astronomy, Ohio State University.

equatorial, forming the northern end of the main building at whose southern extremity is the dome, not yet completed, for the great thirty-six inch telescope.

The meridian circle house is large and roomy and furnishes an admirable receptacle for the noble instrument which it shelters. The building consists of two independent walls, connected only by the window casings and separated by an air space of two feet. The outer wall is of light iron louvre work, the inner one is a mere shell of handsemely finished California redwood. Between the two walls is stretched a curtain of sail cloth to keep out the fogs which in the winter completely envelop the mountain. The instrument itself is still further protected by a sliding canopy which is pushed into an alcove at one side of the observing room when the instrument is in use.

The meridian circle was constructed by the Repsolds of Hamburg, with the exception of the objective of 6½ inches aperture which was made by Alvan Clark & Sons. Although mounted in 1883, it has not hitherto been found practicable to use the instrument for scientific work or even to investigate its constants. The instrument is of the modern type represented in Fig. 25 of Newcomb and Holden's Briefer Astronomy. Ten years ago there was not a meridian circle of this kind in America, but now the observatories at Williamstown, Madison and Northfield possess instruments by the same makers, similar in their essential parts to the Lick observatory circle but not provided with all of the accessories which are here introduced.

A distinguishing feature of the Repsold meridian circle is that the telescope and circles, instead of being supported by wyes and counterpoises fastened immediately to stone piers extending up to a level with the highest parts of the instrument, are carried upon open iron castings which rest upon piers of masonry or stone. These castings also support the microscopes which in the older forms of instruments were usually fastened immediately to the stone piers.

The theory of the old form of mounting was to obtain for

the telescope a massive support which should be, as nearly as possible, immovable. The heavy piers were, however, found to become heated during the day, and at night when the instrument was in use, the brass and steel of the instrument having rapidly cooled off, were subject to a radiation of heat from the warmer piers which introduced errors of an irregular and anomalous character into the results of observation with the instrument. To escape the effects of this storage and radiation of heat the Repsolds, followed by some other makers, have substituted for the upper part of the pier the iron castings above mentioned so that every portion of the instrument, except a small part of the end of the telescope, is lifted above and away from the masonry. The wyes of the Lick observatory circle are fifteen inches above the tops of the piers, the piers are themselves wrapped in a non-conducting material and the whole enclosed in wooden jackets, thus largely reducing the dismal range of temperature of the piers as well as protecting the instrument from their radiation and allowing the air of the observing room to circulate freely about all parts of the instrument.

It must be confessed that an observer familiar only with the massive mounting of the older instruments feels instinctively that the iron castings of the Repsold instrument must furnish an unstable if not an insecure support for the telescope, but experience with such circles, both at home and abroad, has abundantly shown that such is not the case.

The meridian circle possesses two divided circles which are smaller and stiffer than those ordinarily made by other makers for an instrument as large as this. Each of these circles is divided to two minutes (2′) and is read by four micrometer microscopes. One of the circles is firmly clamped to the axis and remains always in the same position; the other turns freely about the axis and may be clamped in any position relative to the fixed circle, thus affording a means of eliminating the effect of division errors in the determination of a star's place by observing the star successively upon different parts of the circle, while with a fixed circle the star for a given posi-

tion of the clamp is always observed upon the same divisions. The division lines upon the circles are purposely made very coarse, the width of each line being about 12″. This, in connection with an admirable and very ingenious system of illuminating the circles, makes the pointing of the micrometer microscopes upon the graduation very easy and rapid without at all impairing its accuracy. The probable error of a single micrometer pointing is about 0.11″, which compares very favorably with the corresponding quantity for larger circles with finer lines. The settings of the instrument may be made from either the north or south side of the piers by means of two telescopes of low magnifying power which point upon the same division of the fixed circle, thus avoiding the necessity for small setting circles. Both telescopes are enclosed in a single tube pointing north and south and viewing the fixed circle by means of prisms placed before their objectives. The field of view of these setting telescopes is about two degrees, and as every degree mark on the circle has its number engraved opposite it, there is always at least one number in the field of view, and the setting of the instrument is made by turning it until the proper division on the circle comes under a thread stretched in the focus of the setting telescope. One lamp placed on each side of the instrument in the prolongation of the rotation axis serves to illuminate the setting telescope, all of the microscopes, the microscope heads and the transit and micrometer threads at the eye end of the telescope.

The telescope is provided with two complete eye ends, with a suitable battery of eye pieces. One of these has the ordinary spider line transit threads and a printing declination micrometer. This eye end I have not used and can say nothing as to its performance. The other carries a ruled glass reticle mounted upon a micrometer by means of which the collimation can be measured and the reticle set so that the collimation constant shall be zero. The declination micrometer has the ordinary divided head which must be read by the observer after each bisection of a star. Both eye ends are provided with rapid motion screws in hour angle and declina-

tion, so that a large field is secured even with high power eyepieces.

The collimators of this instrument deserve special mention. They are telescopes with Clark objectives of 6½ inches aperture and are the equals in optical power of the meridian circle telescope. These large objectives are desirable for many reasons, among which may be mentioned the increased precision of the pointings of the collmiators upon each other and the utilizing of the whole objective of the meridian circle telescope in determinations of collimation and horizontal flexure. Recent experiments with the transit circle at Greenwich have shown the latter to be a matter of importance.

The meridian circle is provided with east and west collimators and a telescope in the rotation axis by which the figure of the pivots may be investigated. No investigation of this kind was possible in the time at my disposal.

The observations of a single month, made under unusual circumstances and with an unfamiliar instrument, cannot be relied upon to indicate the quality of the results to be expected from the instrument. I find from the data available that the probable error of a clock correction and an equator point from a single star are respectively $0.03s \sec \delta$ and $0.5''$. It is probable that these quantities can, under more favorable conditions, be considerably diminished.

The atmospheric conditions prevailing upon Mt. Hamilton attest the wisdom of its selection as the site of a great observatory. From July 24 to August 23 there was no night upon which meridian observations would have been impossible and but three upon which clouds would have appreciably interfered with observing. The average "seeing" during that period I should estimate at four on a scale of five.

The rapid progress which the Lick trustees are now making toward the completion of the observatory justify the expectation that within a year regular observations may be begun with this instrument. Eleven years have passed since James Lick executed the deed of trust by which he provided for the erection of the Lick observatory, and dissatisfaction has some-

times been expressed that its completion has been so long delayed, but the candid visitor to Mt. Hamilton who contemplates the magnitude of the work which has there been accomplished and the difficulties under which it has been carried forward, must concede that if haste has been made slowly it has been made wisely and that the scientific world is under a debt of gratitude not only to the founder of the Lick observatory but also to the gentlemen who have for so long disinterestedly given their time and their talents to the accomplishment of a work which now approaches its successful completion.

INSTRUMENTAL PHOTOMETRY.

By HENRY M. PARKHURST.

[Reply to the paper of S. C. Chandler, at the meeting of the A. A. A. S., Aug. 23, 1886.]

I was reminded of the pertinacity with which Hevelius adhered to plain sights, after the proposition was made to introduce telescopic sights. By his skill and experience he was able, either to equal the accuracy of the observations by the new method, subject probably at first to systematic errors of collimation, parallax, etc., from the lack of attention to such details, or so nearly to equal it that in the absence of accepted standards of comparison it could not easily be demonstrated that his observations would be improved by his adoption of telescopic sights.

It is not necessary, in order to prove the superiority of the instrumental photometry, that we should deny that after years of experience, mere comparisons can be as accurately made. It is enough to show that instruments can take the place of the skill derived from long experience. I well remember, at the second meeting of this Association, in 1849, when Prof. Sears C. Walker first exhibited to this section, Saxton's chronograph, his statement that a child in observing transits could equal the accuracy of trained observers with the eye-and-ear method. Training will no more make an observer than it will a poet. I

do not think that any amount of training would ever make my estimations of brightness as reliable as those of Chandler, Sawyer, or the observers at Cordoba. But my instrumental method only requires me to judge of a single degree of brightness, and that is not difficult to learn.

We are now looking upon instrumental photometry in its infancy, and have a right to expect more from it hereafter. If steam can lift the lid of the tea-kettle, we may expect it to "drag the slow barge and drive the rapid car." If to-day, notwithstanding all the unknown sources of systematic error, an instrumental method will yield tolerable results, we may reasonably expect to develop from it a method which will yield good results.

Before the invention of the clock, it was practicable to obtain the right ascensions of the stars with some degree of accuracy, by observing them in sequences, estimating the intervals of time. I have sometimes accidentally applied that method in my photometry, forgetting to put my watch to my ear, and not discovering until after the extinction that I had been recording the time without its aid. Some one brings to the astronomer observing transits in sequences, a watch, with a crown wheel scapement, running down in an hour. He tries it, and says he can do better without it; its rate changes too fast. But an unskilled observer takes that watch, ascertains how much its rate changes from minute to minute, and then, by winding it every half hour he can at once get more accurate results than would be possible without it; and furthermore, that watch may develop into the dead-beat scapement, or the compensation pendulun of the astronomical clock.

The method of sequences in photometry will yield useful results; but while there is no way to insure the equality of the scale in different parts, as there would be none in observing transits by estimation, there is the additional disadvantage that there is no way to connect the ends of the scale. It does not return into itself, as the star returns to the meridian at the end of twenty-four hours. So we find that Argelander, with all his experience, when he reaches the 8 mag. begins to crowd

his scale, so that by the time he reaches 9.5 mag. he has really reached the 10.5 mag. upon the same scale he employs for the brighter stars. Mere estimations cannot correct themselves. For this purpose instrumental photometry is a necessity.

Another great advantage of instrumental photometry is its freedom from bias. When I compare a series of stars by estimation, I cannot compare the same series again on the same evening, or even months later, without danger of bias. But instrumental observations can be repeated immediately without possibility of bias.

What is most important is to discover the sources of systematic error. As I have a photometric method of my own, and as Mr. Chandler may yet subject my results to the same criticism he has applied to others, (and I wish he would,) let me say here that my observations of long period variables have generally been as bad as I could make them, and for this reason: In order to discover the sources of systematic error, and to test my apparatus under the greatest variety of conditions, I have made it a rule, in taking a second series of observations within a few days, to make the conditions as different as I could; and especially where I suspected an error, I have endeavored to exaggerate that error beyond anything which need to occur in practice. I have not yet reached the position in which I should be willing to undertake elaborate work, although I think the apparatus better adapted for accurate results, in certain departments of stellar photometry, when properly constructed and arranged, than any other.

Most of the instrumental methods have been subject to serious systematic errors. The method of diminishing the aperture, with which I commenced about thirty years ago, is subject to an error, exceeding a magnitude, from the brighter stars being extinguished in a darker field. Optically diminishing the aperture by a bar across the interior of the telescope, has the same effect. The amount of this error can be ascertained, and the correction applied; but I am not aware that it has ever been done.

Pritchard's wedge is subject to the same error from illumin-

ation, provided it is so constructed as to observe all the stars visible with the aperture employed.

My own method is not affected by any error from illumination; but there may be an error of diffraction with this photometer, as also with the method of extinguishing apertures, or with Photometer I at Harvard. I have assumed that the Nichol prisms gave a reliable standard, and have therefore corrected my scale to correspond.

Pritchard's wedge, as it is used, is not subject to the error of illumination, since it is constructed to be used in a black field. As it is not my purpose now to criticize but to defend instrumental methods, I will not take up your time with my objections to it.

It is my own opinion that the Harvard Photometry is subject to the inaccuracy to which Mr. Chandler has referred, and which may be hereafter rectified, either by the original observations, or by additional observations made for that purpose. It is not the fault of the meridian photometer; but if I am right it makes the results appear more discrepant than they really were.

I think it was when experimenting with my disc photometer, that the idea occurred to me that there ought to be a correction for atmospheric obscuration. I made a series of observations to determine the law and the amount of the correction, and formed a table which I submitted to Dr. Gould, who had not yet gone to Cordoba. Dr. Gould referred me to Seidel's table, of which I had never heard. Upon comparison I found that they were practically identical. But the atmospheric correction is not uniform. My conclusion was that we should apply a correction *ao*, *a* being a constant to be determined from the observations of the evening, and which may exceed 3 or be less that ½. This constant for the evening, *a*, not being employed at Cambridge, leads, in my opinion, to discrepancies which might be avoided, or at least diminished.

While therefore I do not believe we have yet reached perfection in the use of any photometric instruments, and while what is called photometry is not after all really measurement

of light, but rather estimation of light assisted by instrumental means, yet I believe it is to instrumental photometry that we must look for our standards henceforth in all our work; and with these standards, the results of skilled observers, by mere estimation, may for a long time to come be as valuable and as reliable as those of observers by instrumental methods.

P. S.—When the above was written I had not access to the Harvard Photometry. I find that for northern stars, down to the southern tropic, the error resulting from the omission of the coefficient *a*, would be nearly inappreciable in comparison with errors of observation. It may require a laborious investigation to determine how far the want of uniformity in the atmospheric absorption affects the results for other southern stars observed in a northern latitude.

ELECTRIC PHENOMENA IN THE SOLAR SYSTEM.

By JACOB ENNIS.

The article with the above title by Professor HEYWOOD in the March number of the MESSENGER, is interesting because it is the first attempt, after my own, to show that the aurora borealis and the tails of comets are driven off in their peculiar directions by an electric repulsion from the sun. My Memoir on these subjects was published by the Academy of Natural Sciences of Philadelphia in their Proceedings for the year 1878. Separately it is a pamphlet of twenty pages closely crowded with facts, and may be obtained gratuitously on application by mail to myself, at 216 Congress Street, Houston, Texas. It is entitled the Electric Constitution of Our Solar System. Prof. HEYWOOD does not show where the electricity in the sun, in the comets, and in our atmosphere comes from. Its origin is evaporation. A gill of saline water is changed into about thirty gallons of vapor highly electrified. The rain fall around our globe is at least on an average thirty-six inches a year. This shows the amount of saline water evaporated from the ocean. And the amount of the electric fluid rising

daily in our atmosphere is great beyond our conception. Only a very small part of this fluid comes down as lightning. The chief mass of it rises up and is carried by aerial currents toward the poles. From there it is driven off, like the tail of a comet, away from the sun.

Sir John HERSCHEL, in his admirable "Outlines of Astronomy," Art. 570, proves undeniably that the tail of a comet springs from evaporation. The corona of the sun I have shown in my Memoir to be of the same nature as our auroral streamers, and as the cometic tails. Since then the coronal rays have been seen to extend outwardly ten millions of miles. In no known place in creation is there such abundant evaporation as in the sun. The red vapors called the chromosphere are constantly raging and flashing and shooting up to the height of from ten thousand to a hundred thousand miles. The amount of electricity to form the solar corona which this evaporation may liberate, is beyond our conception.

I am not aware of any collection of facts which proves, as Prof. HAYWOOD asserts, that the aurora borealis is most frequent in the winter. It is well established to be a daily occurrence and seen nightly in the auroral zone far to the north all around the globe. It goes round and round from east to west, in the shadowy cone of the night, affording beautiful illumination through certain regions in the base of that cone. Its occasional brilliant exhibitions seen down to latitude 40° and lower, appear to be caused by special electric repulsions from the corona of the sun. The force of that corona must vary wonderfully, and the variations in our aurora must correspond. At some solar eclipses the corona rises not more than a quarter of a million of miles high. At the total eclipse of 1878 it reached upwards, or outwards, some ten millions of miles; that is, twelve solar diameters. See Prof. S. P. LANGLEY'S report to the observatory at Washington, D. C.

The electric manifestations, the lightning and the thunder, are not the cause, but they are the effect, of the summer showers. Therefore, being meteorological and not astronomical, they need not be discussed here.

At the period of writing my Memoir I had been perplexed with several facts where the streamers darting away from the sun and from the comets, did not proceed straight out and in right lines, but obliquely and in curved lines. These seemed to show that they were not of the same nature as our aurora borealis, whose streamers rise vertically. But in an unusually great display of March 15th, 1885, as reported in the United States weather reviews for that month, page 71, the streamers were *inclined*. The passage reads as follows: "Spokane Falls, Washington Territory. A bright aurora appeared at 11:10 P. M. There were three streamers of light pink color, which rose and fell at short intervals; these streamers were not vertical, but were inclined toward the west." This is important, for it aids to identify the tails of comets and the corona of the sun with our aurora, which is well known to be an electric outburst, pointing, like them, away from the sun.

Only one author, as far as I am aware, has opposed my position that all these great phenomena are of the same nature. His objection is that the spectra of their light are all different. This is but a slight opposition, and easily overcome. Every one knows that the spectra of objects vary greatly with temperature, pressure, allotropic condition and other circumstances. In these ways it happens, according to the admissions of the same author, that some elements may have as many as four different spectra. Now the circumstances out of which these great electric brushes arise from the burning sun, from the distant and freezing comets, from our northern zone of the aurora, and from the tropical region of the zodiacal light, all differ essentially. We cannot conceive why these electric brushes should not carry off with themselves small particles of the vapors out of which they spring. And these vapors must all differ from one another, as our viewless watery vapor differs from the red vapors of the solar chromosphere. These illuminated particles carried away must vary the spectra. Our aurora borealis strongly varies its colors. Although generally white and colorless, yet sometimes, as just stated, it may be pink and at others it may be deep red, or green, or

yellow, or purple. The something which changes its colors may, and likely must, change the spectra. But enough. The precious space of the MESSENGER must not be occupied by a repetition of the facts contained in my Memoir aforesaid.

THE "RED LIGHT."*

HENRY C. MAINE, ROCHESTER, N. Y.

The appearance of what are known as the red sunsets or red light, in the autumn of 1883, is regarded as one of the most remarkable meteorological events of modern times. The strange feature of the red light was its long duration after sunset, and a peculiar halo or corona about the sun by day. The light after sunset was usually of an orange red or a rose color, and reached far up toward the zenith in the form of an arch, with a bright spot at the highest point. There was also a bright spot and colored arch in the east, opposite the sunset point, as if produced by reflection. The horizon to the north and south was also lighted with red until a late hour, sometimes 9 o'clock. On a few occasions the light assumed the form of alternate sections of rose color, and blue sky, with auroral action in the colored streamers. One of the most interesting exhibitions of the kind was upon the 19th of September, 1885. At nearly every exhibition, when the rose color was prominent, auroral action could be detected. The phenomena of the sunsets changed rapidly, arch succeeding arch with changing colors as the sun went lower and lower. The halo by day had an ashen or salmon tint on the outer border, which shaded into the sky. The border was irregular, being extended in various directions at different times. (See photograph No. 2.)

The ordinary ring or halo about the sun has edges well defined, with more or less display of prismatic colors. (See photograph No. 3.)

* The western sky was colored a bright roseate hue last evening and all around the horizon and up to the zenith the clouds were fringed with red, a repetition of the red sunsets of last summer. This is the first time the phenomenon has been seen in any degree of magnitude this season.—*Portland Morning Oregonian, July 4, 1885.*

The first step in determining the cause of the halo and unusual prolongation of sunset effects was to ascertain if they corresponded in time and intensity with other phenomena, and then determine the probability of physical connection. When the red light appeared, the sun was near its maximum of activity or spottedness, and the earth had been vexed with the most violent storms, and floods had been very destructive.

No. 1.—The Rosy Sunset of November 22, 1885, photographed by Henry C. Maine, showing the rosy arch and the brilliant light below it near the sun.

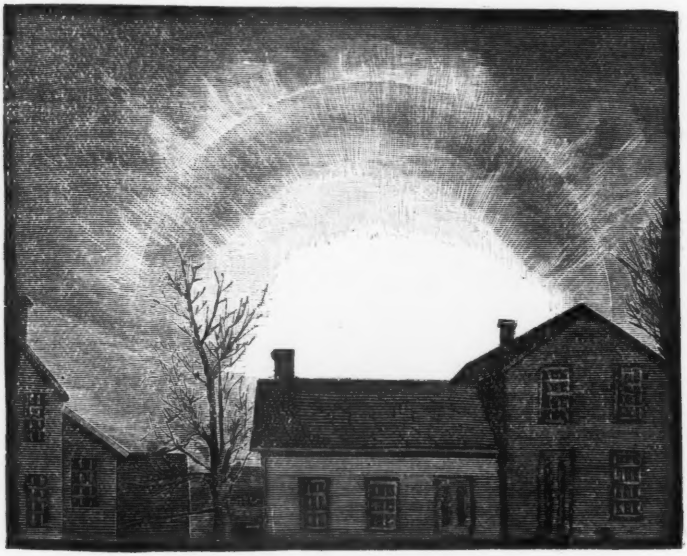
Having observed the sun daily, since the solar activity began to increase after the minimum of 1878-9, with the result of noting a correspondence in time of the most terrific storms on the earth with similar disturbances on the sun, observation was extended to the red light. A brief record of the most prominent sunset displays must suffice :

There was great solar disturbance at the time the green suns and red sunsets appeared in the equatorial belt, in the beginning of September, 1883. The green suns were seen at Panama on September 2, and at Trinidad on the same date. On the 1st of September twenty new solar spots appeared, and on that date there were seven groups and ninety-five spots one of which was visible to the naked eye. There were cyclones of great energy in the equatorial seas at the time, and the

No. 2.—The Red Light Halo about the sun, photographed by Henry C. Maine, November 22, 1885. The vapors near the horizon are also lighted and of considerable actinic energy. A salmon color appeared in the faint outer haze surrounding the central brightness.

captain of a dismasted vessel was one of the first observers of the strange light in the sky. The red light appeared in Western New York on November 24, 1883, after a severe storm had passed over the great lakes. There was great solar disturbance at the time and the light was at a maximum on the 27th. On

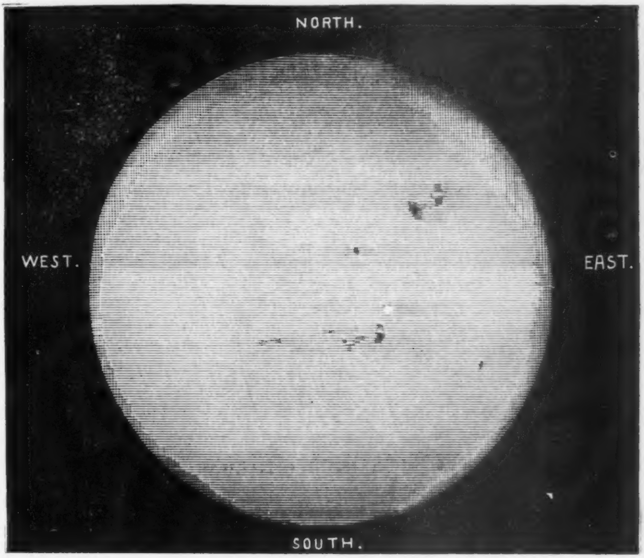
that day, the ashen halo, mentioned above, was very conspicuous. This persisted with slight changes for more than a year. On the 2d of December the red light was not seen in Rochester, and the sun was nearly clear of spots. A number of new spots appeared on the 6th, and on the 8th the red light re-appeared. It brightened until the 10th, when it was very brilliant. The red light faded as the sun storms disappeared



No. 3.—The Sun, June 18, 1885, photographed by Henry C. Maine.

by the sun's rotation. December 21st a spot area of large extent appeared, followed by great meteorological disturbance, and the red light shone again, reaching great brilliancy on the 26th of December. This maximum was also noted by Dr. F. A. Forel, at Morges, Switzerland. The light waned until January 1st, when there was an ordinary sunset. On January 2d active sun storms appeared and on the 3rd, after an electric storm, which drove telephone operators from their instruments

in some places, the red light re-appeared. After a great storm, the light was brilliant January 9th and morning of the 10th. On the 17th the light was brilliant, following new solar storms. On January 25th the light was very bright, following a great chain of sun storms. Hurricanes occurred in England on the 22d, and in France and England on the 26th. The red light then decreased in brightness. On the 11th of February active sun storms re-appeared ; tornadoes occured in the south on

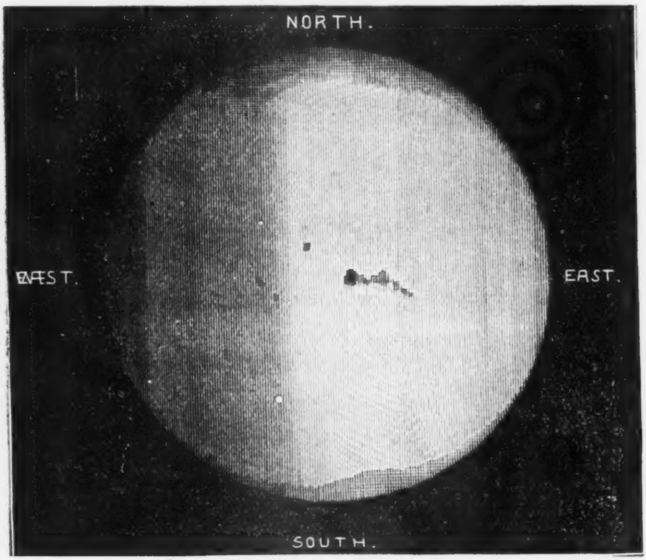


No. 4.—Great Group of Sun Spots, June 18, 1885, photographed by Henry C. Maine.

the 13th and the red light was noted on the 14th. On the 19th two new sun storms came, the red light increased, and six southern states were swept by tornadoes. The sky was of a lurid red at midnight, probably from electric action upon vapors of the atmosphere. A new sun storm came February 24th, and the light continued brilliant, but faded in a few days. [The greatest brilliancy of red light, and severest terrestrial storms

were noted when sun spots were between the eastern limb and the sun's meridian.]

On March 2d, 5th and 6th, new sun storms appeared and the light shone brightly. A destructive general storm followed. More sun storms came on the 13th and 14th and the red light was at a maximum on the 17th. Then there was a descent toward a minimum. March 25th, a sun storm developed on the sun's

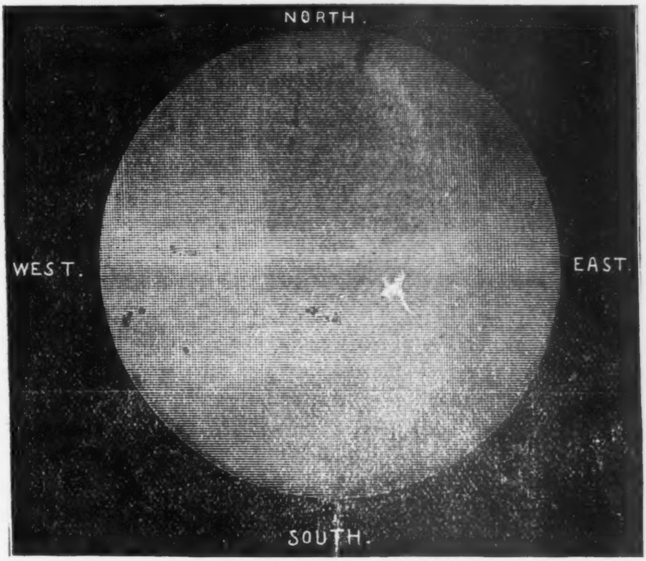


No. 5.—Great Actinic Energy about a Solar Storm or Sun Spot Group, June 20, 1885, at noon, photographed by Henry C. Maine.

disc; tornadoes swept seven states. The sun storm developed the largest group of spots seen up to that date. The red light shone with remarkable brilliancy on March 27th. April 1st a great chain of sun spots appeared; tornadoes followed in five states and on the 5th the red light was intense.

Thus the light fluctuated through the entire spring and summer of 1884. In the autumn of that year the skies were very brilliant at intervals, always corresponding with the intensity

of solar action. In the late winter and spring of 1885, the sun storms began to diminish, the red light nearly disappeared and the peculiar halo about the sun was no longer conspicuous. Toward the middle of May there was a marked renewal of the solar storms, and by the first of June the spots were very numerous and large. During June the sun was the seat of con-



No. 6.—Hydrogen Cloud on Sun, June 12, 1885, at noon, photographed by Henry C. Maine.

vulsions of the most remarkable character (see photographs of June 20th and other dates,) accompanied by a long series of very destructive storms in all parts of the world. Early in July the red light re-appeared. On the 5th it was seen in Rochester, and in Oregon two days earlier. On the 31st of July the brilliancy of the red light reached a climax. The bright, rose colored spot above the sunset point again lighted objects like a second sunset, and appeared self-luminous.

The sunsets at this date were, as I observed, mostly of a rose color, which varied in intensity. They continued with varying brilliancy through August. The halo about the sun had re-appeared as a white corona, which increased in density until the salmon color on the outer border was noted again on the second of September as very conspicuous, as was also the red light. The halo still persists and was quite brilliant on the day of the annexed photograph, November 22, 1885. By reference to the records of the signal service, it is noted that the red light varied in intensity at different places on the same date, showing conclusively that local conditions must have had a part in producing the phenomena. The best observers reporting to the signal service noted the difference between the orange† and rosy sunsets. The red light continued during September with the usual fluctuations‡, being very brilliant on the 14th, and some days thereafter, following a great solar disturbance preceding the Washington Court House tornado.

These observations show that these phenomena, great storms on the sun, extended and severe meteorological disturbance on the earth, and the red sunsets, corresponded in time and intensity. The fluctuations of the red light also corresponded with the periods of change in solar agitation.§ Is there a fair presumption of a physical connection?

The persistence of the peculiar halo about the sun for more than a year, while the red sunsets were very unequal, sometimes disappearing altogether, indicates that there must be several factors to produce the sunset phenomena. Some of these factors were less changeable than the others. The halo

†Vevay, Indiana: Yellow or orange sunsets were observed on the 1st, 5th, 13th, 15th, 17th, 20th, 28th and 30th. Rosy sunsets were observed on the 3rd, 8th, 9th, 10th and 16th.—*Signal Service Monthly Weather Review for August, 1885.*

‡The color of the skies after sunset again deserves note. Many observers record especial coloring on dates from the 12th to the end of the month. The colors are variously described as orange, crimson and pink.—*Bulletin of New England Meteorological Society for September, 1885.*

§M. Faye says: "It is what may easily happen in the progress of a periodic phenomenon which passes rapidly and without fluctuation, from a minimum to the following maximum, but which passes slowly, by a series of secondary oscillations, from the maximum to the following minimum. This is, in effect, the well-known progress of solar spots.

showed but little change for a long period although it was noted that on most occasions the red light was brilliant at night, when the halo was most conspicuous. What was the condition of things which rendered the halo persistent while the sunsets changed, almost wholly disappearing at intervals?

A terrific volcanic eruption in the Straits of Sunda, Island of Java, on the 26th of August, 1883, has been regarded by many as the cause of the red sunsets. It has been held that the dust from the crater spread over the whole atmosphere of the globe at a great height, reflecting back the sunlight, after the sun had set, for a greater length of time than was usual. If the medium of reflection were dust suspended permanently in the atmosphere, and if the dust caused the solar halo, the presence of the halo about the sun by day ought to prove the presence of the dust, and the red sunsets, which are supposed to have been dependent on that dust, should therefore have been uniform during the time the halo was visible. But the sunsets were not uniform during that period as has already been shown. This does not, however, wholly exclude the dust as a possible factor. But it is difficult to conceive how dust could remain in suspension at so great a height for more than a year, then disappearing for a time and returning again last July and August. To explain the long suspension of the dust, those who adhere to the "dust theory" have assumed that it may be mingled with water vapor at a great height. Judging from observation, and the remarkable localization of the red sunsets on many occasions, as before noted, water vapor must be considered a very important factor in their display. The maintenance of water vapor at a height sufficient to reflect or refract the light of the sun after it is twenty degrees below the horizon, a distance which has been calculated by Mr. Serviss and others, requires unusual conditions. Where shall the conditions be sought? Do they exist in the earth itself or its atmosphere? Evidently they do not. Then they must be sought outside, and can be found nowhere except in the sun. The sun's intense activity during the past five years supplies all the conditions necessary to raise the vapor, by added heat and electri-

cal action, to an abnormal height. But the same condition of the sun which would elevate the vapor to a great height, would also greatly increase the evaporation from the waters of the globe and give rise to excessive rainfall. As a matter of fact, such rainfalls have occurred and are now occurring.

Proceeding a little farther, it will appear that a condition of the sun which would produce the effects noted, must also have some appreciable effect upon the sun itself and its immediate surroundings or vaporous envelope. In an annexed photograph (No. 6) of the sun, June 12th, 1885, will be seen a luminous cloud of enormous dimensions, apparently floating high above the sun's surface, for it is brighter than the sun itself. This matter, (probably blazing hydrogen) if it does not pass out among the worlds of the solar system, goes to increase the nebulous matter about the sun. During the extended maximum of solar activity, (which has been stretched out two or three years beyond the ordinary limit,) this matter has passed out almost continually into the vapor envelope of the sun, as smoke and vapor rise in our atmosphere. But this sun vapor rises with much greater velocity from the sun, as the attraction of the sun is greater than that of the earth. The great increase of the eruptions of sun vapor during the present sunspot maximum, would enormously extend the vapor shell about the sun. If the earth is involved in an envelope of its own dust thrown to an unusual height by the Java volcano, as the "dust theorists" claim, how much more must we expect the sun to be involved in its own vapors, since the activity there exceeds by a million or more times the feeble efforts of a world cooled sufficiently to be inhabitable. The sun has the reputation of being a nebulous star. Tennyson says in "The Princess":

> "There sinks the nebulous star we call the sun,
> If that hypothesis of theirs be sound."

Nearly every astronomer who has observed the sun has observed the passage of vast, luminous vapor clouds, mostly hydrogen, into the sun's atmosphere, or away from the globe

of the sun. Prof. Young saw such an event in 1871 and recorded it. The cloud rose to the height of two hundred thousand miles from the edge of the sun, at the rate of 167 miles a second, before it faded from view in the spectroscope. Prof. Young calculated that the first outburst of. this vapor must have been at the rate of at least 300 miles each second. Louis Trouvelot, at Meudon, near Paris, saw a mass of luminous cloud move out from the sun on the 16th of August, 1885. The observers at New Zealand of the total eclipse of the sun, September 9, 1885, saw with the naked eye a red flame shoot out near the rift of the corona. So far as known, no such vapor cloud was ever photographed until last June, except during a total eclipse. Prof. Young said in his address before the American Association for the Advancement of Science, at Philadelphia, in 1884: "As regards the actual existence of an extensive gaseous envelope around the sun, it may be added that other appearances than those seen at an eclipse seem to demonstrate it beyond question—phenomena such as the original formation of clouds of incandescent hydrogen at high elevations and the forms and motions of the loftiest prominences.

Besides the reasons already stated for believing the sun's vaporous envelope is enormously extended during great solar activity, there is another which is most pursuasive, and which explains a puzzling matter in a reasonable way. That matter is the peculiar retardation of Encke's comet during certain of its perihelion passages, and absence of retardation at other passages. Prof. Simon Newcomb says in his Popular Astronomy: "Dr. von Asten found that between 1861 and 1865 there must have been a retarding action like that supposed by Encke. Carrying his work forward to 1875, he found that between 1871 and 1875 there was once more evidence of a retardation about two-thirds as great as that found by Encke. The absence of such an action between 1865 and 1871, therefore, seems quite exceptional and difficult of explanation."

It will be seen by reference to the past records of solar activity, that the years of retardation were years during or im-

mediately following maximum solar disturbance. The comet was probably retarded then because the solar envelope was greatly extended; and the comet had to move through the vapors thus sent out into space by the eruptions below. When the solar activity in a measure subsided, towards the minimum period, the vapor thus thrown out condensed and returned to the sun, or was dissipated in space. So the comet would meet with less resistance upon another return. It was the opinion of Sir William Siemans that the matter thrown out from the sun's equatorial regions passed out beyond the earth's orbit and returned again by re-curving to the sun's poles. If this theory is true, more matter would pass out from the sun during maximum solar activity than at other times.

Bearing all these facts and theories in mind, is it not probable that the violent solar eruptions during the past five years have so loaded and extended the solar envelope that the nebulosity has become visible, and that the visibility began in the autumn of 1883? The effects of the solar eruptions upon our atmosphere might have been such as to aid in rendering the sun's envelope visible through vapor at an abnormal height. Such conditions explain the persistence of the solar halo, and its changes in form, while the sunset phenomena, which depended partly upon local atmospheric conditions, varied from day to day. The halo or corona about the sun itself may have been exaggerated to our view greatly beyond the actual limits of the solar envelope, by the condition of our atmosphere. Indeed, part of the display must be atmospheric. Suppose an extension sufficient to retard Encke's comet, which had a perihelion distance of about 30,000,000 miles, and it will not be far from the corona which persisted from November 24, 1883, for more than a year, and is still seen at intervals after great solar activity and meteorological disturbance on the earth. But the corona of the present maximum period must be much greater than the coronas which were encountered by the comet on the dates mentioned by Dr. von Asten.

Given this corona or envelope with sufficient density towards its outer edge to reflect the sunlight, and we have the rose

colored arch, with its bright spot, which followed the sinking of the sun, with the brilliant reflection in the east; also the sunrise effects, which were quite as notable. Given this corona, and the character of this sunset would change from day to day through the changing condition of the vapor and possibly volcanic dust in our atmosphere. When the atmosphere was heavily laden with vapor and possibly dust from Krakatoa, the arch would be lost in the orange red glow of the gorgeous sunsets, as on November 27th, 1883, and later dates. When the dust had settled, if it was ever in our atmosphere, at the latitude of New York, the rosy arch would persist as it did and the corona would remain also by day. The arch lighted the dust and the watery vapor and the image of the arch was projected on our atmosphere; but when both dust and vapor were at a minimum, the arch alone was seen, with a faint rose color. This color is the one that might be expected from the character of the vapor, mostly hydrogen, in the sun's envelope or corona.

Prof. C. A. Young says in his work on the sun, page 207: "The observations of the eclipse of 1871 by Lockyer and others show that hydrogen in a feebly luminous condition is found all around the sun, and at a very great altitude—far above the ordinary range of prominences." This observation was near the sun spot maximum, and this accounts for the success of the observation, when luminous hydrogen was not observed at other eclipses.

The slightly varying brilliancy of the rosy arch, and of the halo by day is accounted for by the varying energy of the solar erruptions, the condition of the sun changing the condition of the envelope about it, and also affecting the earth's atmosphere. The auroral action of the red light is also dependent upon the solar condition.

With the corona receiving and reflecting the sunlight after the sun had set, it is not necessary to conceive that the water vapor was raised to so great a height as to reflect the sunlight after the sun was twenty degrees below the horizon. But the vapor must have been elevated considerably, as the condition

of the sun and the excessive evaporation would warrant this. But such elevation to fit any theory must depend upon the sun and its increased activity. The duration of the red light after sundown was varied by the varying height and density of the water vapor or dust, which were dependent upon metero-logical conditions.

Prof. Balfour Stewart, the eminent director of the Kew Observatory, says that "the magnetical and meteorological processes of the earth are most pronounced when there are most sun spots." The intensifying of terrestrial meteorology has been so pronounced during the past five years that no argument is necessary here. The record of the tornadoes, cyclones and floods is a part of the history of those years, and is spread out everywhere in the daily press.

From all these considerations it would seem that there is a reasonable presumption of a physical connection between the unusual solar activity and the red light, and that the one is the principal cause of the other.

ADDENDA.—My attention has just been called to the following from the *Scientific American* of the 2d of January, 1886. I presume it had not before been published in this country; and appearing a month subsequently to the date of my essay, in which the same views of the corona were independently advanced, it should not interfere with my claim to original treatment. I trust that you will submit this note with accompanying extract as an addendum to the essay of "OBSERVER."

Prof. Tacchini, a great authority among scientists, gives a remarkable piece of information in a letter to *L'Astronomie.* He records that M. Faval asserts that on high mountains, when the sky is serene, the solar corona is so apparent that it strikes all observers. The mountaineers and dwellers among the Alps agree in affirming that the phenomena is something entirely new. Tacchini also gives an experience of his own on the subject. He made the ascent of Mt. Etna in July last. When near the volcano, at a height of over 10,000 feet, under a clear

sky of a dark blue tint, he saw the sun surrounded by a white aureola, concentric with a magnificent corona of a coppery red. The corona was transformed near the horizon into an arc less defined and of much greater extent.—*Scientific American, Jan. 2, 1886.*

ORBIT OF THE BINARY STAR GAMMA CORONAE AUSTRALIS.

H. C. WILSON.

For the Messenger.

The double star γ *Coronae Australis* is one of the most interesting of southern binaries. The components are of about the 6th magnitude and almost exactly equal. The position of the star, R. A. 18*h.* 59*m.*, Decl. —37° 18′, is unfortunately too far south for good observations in the northern hemisphere. Its duplicity was discovered in 1834 by Sir John Herschel at the Cape of Good Hope. Elements of its orbit have been published by Captain Jacob in 1855 (Mo. No. R. A. S., Vol. XV), Prof. Schiaparelli in 1875 (Astr. Nach. No. 2073), Mr. Downing in 1883 (Mo. No. R. A. S. Vol. XLIII), and Mr. Gore in 1886 (Mo. No. R. A. S. Vol. XLVI).

As an exercise, I have, in my spare moments during the last month, computed an approximate set of elements, using the graphical method given in "A Handbook of Double Stars," by Messrs. Crossley, Gledhill and Wilson, and including a number of observations of recent date, not yet published. The results are given side by side with those obtained by other computers:

ELEMENTS OF γ CORONAE AUSTRALIS.

Computer.	Jacob.	Schiaperelli.	Downing.	Gore.	Wilson.
	°	°	°	°	°
Position of Node	352.2	229 2	227.4	45.0	41.0
Inclination	53.6	111.4	69.3	47.4	50.5
Position of Periastron	256.2	304.5	284.0	141.0	139.0
Eccentricity	0.602	0.699	0.697	0.322	0.324
Period in years	100.80	55.58	54.98	81.78	78.80
Periastron passage	1863.08	1882.77	1883.20	1886.53	1887.40
	″	″	″	″	″
Semi axis major	2.55	2.40	2.44	1.88	1.85

The large differences between these elements show the uncertainty of orbits derived from an insufficient number of observations. Below are given all the observations upon which my elements depend, together with the differences between the observed and computed position angles and distances. It will be seen that the position angles are well represented, with the exception of those by Powell from 1859 to 1864, which seem to be affected by systematic error. The distances are not so well represented.

Epoch.	Observer.	Position Angles.	Distance.	Differences P. A.	*o—c* Distance.
		°	"	°	"
1834.47	Herschel	36.8	......	—0.6	......
35.55	"	36.5	......	+0.8	......
36.43	"	34.2	......	+0.4	......
37.43	"	32.4	2.66	+0.4	+0.37
47.32	Jacob	13.9	2.30	+0.5	+0.17
50.46	"	5.7	2.29	—0.9	—0.27
51.54	"	4.3	2.26	+0.3	+0.29
52.49	"	2.0	1.90	+0.3	—0.03
52.72	"	0.8	1.90	—0.2	—0.02
53.52	"	358.8	1.83	—0.1	—0.04
53.71	Powell	358.4	......	0.0	......
54.11	Jacob	356.6	1.80	—0.7	—0.04
54.78	Powell	355.4	......	—0.1	......
55.77	"	352.7	......	+0.1	......
56.44	Jacob	349.2	1.67	—1.4	—0.07
57.44	"	347.3	1.61	0.0	—0.08
58.20	"	343.3	1.53	—1.5	—0.12
59.72	Powell	338.0	......	—1.1	......
61.69	"	328.7	......	—2.5	......
62.27	"	325.2	......	—3.5	......
63.84	"	318.0	......	—3.6	......
75.65	Schiaparelli	257.4	1.45	+0.1	+0.11
76.65	Howe	253.1	1.67	+0.9	+0.31
77.43	Schiaparelli	248.4	1.49	+0.1	+0.12
77.61	Howe	245.7	1.37	—1.7	0.00
77.69	O. Stone	249.4	......	+2.3	......
78.49	"	242.4	1.22	—0.8	—0.16
78.49	Howe	242.9	1.47	—0.3	+0.09
79.70	Burnham	240.0	0.87	+2.9	—0.51
80.46	Russell	233.1	1.15	—0.3	—0.23
80.67	Hargrave	232.4	1.32	+0.1	—0.06
81.72	O. Stone	225.5	1.38	—1.5	+0.02
83.62	H. C. Wilson	217.8	1.62	+0.8	+0.32

The differences in the last two columns are almost identical with those obtained by Mr. Gore (Mo. No. R. A. S. Jan. 1886). I think we may conclude that the period is not far from eighty years. It is to be hoped that numerous observations of this star will be obtained during the next ten years, while the distance is small and the angular motion rapid.

MT. LOOKOUT, May 15, 1886.

EDITORIAL NOTES.

This issue of the MESSENGER regularly follows that of July. August and September were vacation months.

In the Section of Mathematics and Astronomy at the Buffalo meeting of the American Association for the Advancement of Science, the following papers were presented:

On the degree of accuracy which may be expected from chronograph records. Wm. A. Rogers.

On a method of determining the constants of Precession which is partially independent of the variations of the Proper Motion of the stars employed. Wm. A. Rogers.

Comparison of Boss' and Auwers' Declination-Standards. Henry Farquhar.

On some mechanical attachments (partly novel and partly not) for facilitating the astronomer's work with the equatorial. David P. Todd.

Change of Latitude of the Sayre Observatory. C. L. Doolittle.

Photographic determination of stellar position. B. A. Gould.

Some account of a new catalogue of the magnitude of southern stars. E. F. Sawyer.

A comparative estimate of methods and results in stellar photometry. S. C. Chandler.

Comparison of the places of the *Pleiades* as determined by Konigsberg and Yale College heliometers. W. L. Elkin.

A neglected correction in the use of Refraction tables. Cleveland Abbey.

Magnifying powers of telescopes. Henry M. Parkhurst.

Telescopic observations of meteor trains. E. E. Barnard.

On the use of Zenith telescopes for latitude. S. C. Chandler.

A new theory of Gravitation. John H. Kedzie.

Apparatus: An instrument to show at any time the direction of the earth in space, in its annual motion. John Haywood.

On a method of obtaining the mean apparent diameter of the sun. Samuel Marsden.

Some of these papers will appear in the MESSENGER later. The substance of some has already been given; all others are solicited.

OCCULTATION OF 4 GEMINORUM BY THE PLANET JUPITER.— In *Ast. Nach.* No. 2741, Mr. H. C. Wilson, of the Cincinnati Observatory, has given a list of occultations observed at Mt. Lookout in the year 1882-3-4. Among them is an occultation of 4 Geminorum by Jupiter on Nov. 7, 1882, and as occultations by a planet are rarely observed, I have thought it worth while to extract this observation and prepare the elements for its reduction.

The position of the planet is taken from the *American Ephemeris* for 1882, and the place of the star from Newcomb's *Standard Stars*.

But one phase was observed, the disappearance, which took at 12*h.* 2*m.* 20*s.*, Mt. Lookout mean time, corresponding to the Greenwich mean time, 17*h.* 40*m.* 1.4*s.* For this epoch the position of the star and planet are as follows:

JUPITER.

		α			δ	
Geocentric	6*h.*	3*m.*	25.95*s*	+23°	1′	7.6″
Parallax			+0.08			—0.7
Apparent	6	3	26.03	+23	1	6.9

4 GEMINORUM.

		α			δ	
Mean 1882.0	6*h.*	3*m.*	20.53*s.*	+23°	0′	57.4″
Reduction			+4.56			—6.1
Apparent	6	3	25.09	+23	0	51.3

From the above we have

$$\Delta\alpha = -0.94s.$$
$$\Delta\delta = -15.6$$

from which we find the position angle and distance of the star, referred to the center of the planet,

$$p = 224.48°$$
$$s = 21.86''$$

NEW YORK, N. Y., Sept. 14th, 1886. JOHN TATLOCK, JR.

On the Nebula 4036 of Herschel's General Catalogue.—In Sidereal Messenger (Vol. III, 1884, p. 189) I called attention to an error in the description of the nebula, G. C. 4037.

The position of this object as given in G. C. is also widely erroneous.

On June 29th and 30th four ring micrometer observations of the nebula were made with the 6 in.

The comparison star was Yarnall, 6205.

The mean of the four comparisons gave

Nebula precedes star by $3m.\ 14.68s.$

Nebula south of star $9'\ 1.4''$

Applying these corrections to the position of the star we have for the place of the nebula:

$$\left.\begin{array}{l} \alpha = \quad 14h. \quad 56m. \quad 58.43s. \\ \delta = -32^\circ \quad 37' \quad 8.1'' \end{array}\right\} 1886.0$$

The description with 6 in. is

S; B; R; vvmbM; probably a stellar nucleus.

Observations corrected for refraction.

Vanderbilt University Observatory, Nashville.

E. E. BARNARD.

Magnifying Power of Telescopes.—The question of the magnifying power of a telescope, when used to form an image of the sun of a specified diameter upon a screen, was recently submitted to various persons, with a great variety of answers. The problem may be said to be indeterminate, but it is no more so than the magnifying power of a microscope. It requires an assumption of the distance of the eye from the image; and it seems proper to make the same assumption that is made with microscopes, 10 inches. This gives the

Rule—Divide the diameter of the image by the sun's apparent diameter in arc with a radius of 10 inches; or for practical purposes it will be sufficient to multiply the diameter in inches of the image upon the screen by 10.

HENRY M. PARKHURST.

RING MICROMETER OBSERVATIONS OF COMETS FABRY AND BARNARD, MADE AT THE LEHIGH UNIVERSITY OBSERVATORY.

COMET FABRY.

Date.	Mean Time.			Δa		$\Delta\delta$		Comparisons.	Apparent a			Log. $(p\times\Delta)$	Apparent δ			Log. $(p\times\Delta)$	Reduction to Apparent Δa	Reduction to Apparent $\Delta\delta$	Star.
1885.	h	m	s	m	s	′	″		h	m	s		°	′	″		s	″	
Dec. 29.	6	46	7.1	+0	56.64	—16	21.9	5	23	47	35.97	9.277	20	46	15.6	.500	—.25	+5.6	*a*
1886. Jan. 1..	6	34	58.6	—2	46.27	—15	23.4	5	23	44	6.15	9.295	20	51	13.9	.501	—.25	+5.2	*b*
Jan. 2..	6	41	30.8	—3	50.50	—13	10.5	5	23	43	1.91	9.341	20	53	26.7	.505	—.26	+5.1	*c*
Jan. 5..	6	30	25.6	—1	2.91	+1	42.1	5	23	40	3.15	9.354	21	1	15.5	.508	—.32	+5.0	*d*
Jan. 5..	6	53	12.2	—1	3.72	+1	43.8	5	23	40	2.34	9.354	21	1	17.2	.508	—.32	+5.0	*d*
Feb. 24.	7	8	38.3	—1	49.32	—2	19.3	5	23	21	4.77	9.707	28	21	41.5	.709	—.80	—0.8	*e*
Feb. 27.	7	17	43.0	+2	15.29	+4	49.1	5	23	20	41.91	9.707	29	7	37.7	.733	—.80	—1.2	*f*
Feb. 28.	7	24	4.9	—1	9.78	+7	46.6	5	23	20	36.41	9.706	29	23	41.4	.744	—.80	—1.3	*g*
Mar. 5.	7	32	6.3	—2	8.87	+3	14.9	5	23	19	57.27	9.706	30	45	40.4	.756	—.81	—2.1	*h*

COMET BARNARD.

Date.	Mean Time.			Δa		$\Delta\delta$		Comparisons.	Apparent a			Log. $(p\times\Delta)$	Apparent δ			Log. $(p\times\Delta)$	Reduction to Apparent Δa	Reduction to Apparent $\Delta\delta$	Star.
Feb. 23.	8	35	17.5	+1	7.54	+16	5.0	5	1	58	58.36	9.658	19	36	49.5	.675	—.28	—4.4	*i*
Feb. 24.	8	1	46.3	—1	26.40	—10	46.8	5	1	58	30.43	9.638	19	52	1.8	.648	—.28	—4.4	*k*
Feb. 27.	7	59	2.3	—0	1.81	—4	2.9	5	1	57	33.31	9.648	20	39	29.8	.551	—.31	—4.4	*l*
Mar. 5.	7	56	11.6	+0	33.63	+0	46.1	5	1	55	10.75	9.668	22	19	14.9	.662	—.40	—4.4	*m*

MEAN PLACES OF COMPARISON STARS.

Star.	a 1886.			δ 1886.			Authority.		
	h	m	s	°	′	′			
a	23	46	36.50	21	2	12.0	W.	23.	954
b	23	46	52.67	21	6	32.1	W.	23.	960
c	23	46	52.67	21	6	32.1	W.	23.	960
d	23	41	6.38	20	59	28.4	W.	23.	850
e	23	22	54.89	28	24	1.6	W.	23.	454
f	23	18	27.42	29	2	49.8	W.	23.	344
g	23	21	46.99	29	15	56.1	W.	23.	421
h	23	22	6.96	30	42	27.6	W.	23.	432
i	1	57	57.10	19	20	48.9	W.	1.	1341
k	1	59	57.71	20	2	53.0	W.	1.	1397
l	1	57	35.43	20	43	37.1	W.	1.	1324
m	1	54	37.52	22	18	33.2	W.	1.	1260

BETHLEHEM, Pennsylvania, April 27, 1886.

C. L. DOOLITTLE.

XUM

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